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# An Evaluation of the Ball-Matic Device A PCV Air Bleed

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Technology Assessment and Evaluation Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Environmental Protection Agency

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16. ABSTRACT

The Environmental Protection Agency receives information about devices for which emission reduction or fuel economy improvement claims are made. In most cases, these devices are being recommended or promoted for retrofit to existing vehicles although some represent advanced systems for meeting future standards. The EPA is interested in evaluating the validity of the claims.and invites proponents of such devices to provide to the EPA complete technical data on the device's principle of operation, together with test data on the device made by independent laboratories. The conclusions drawn from the EPA confirmatory tests are necessarily of limited applicability. Data supplied to the EPA by Ball-Matic, Inc. indicated that their emission control device (called the Ball-Matic)was capable of reducing exhaust emissions. An EPA confirmatory test program was arranged to further investigate the effects of the Ball-Matic on exhaust emissions.

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
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## Background

The Environmental Protection Agency receives information about many devices for which emission reduction or fuel economy improvement claims are made. In some cases, both claims are made for a single device. In most cases, these devices are being recommended or promoted for retrofit to existing vehicles although some represent advanced systems for meeting future standards.

The EPA is interested in evaluating the validity of the claims for all such devices, because of the obvious benefits to the Nation of identifying devices that live up to their claims. For that reason the EPA invites proponents of such devices to provide to the EPA complete technical data on the device's principle of operation, together with test data on the device made by independent laboratories. In those cases in which review by EPA technical staff suggests that the data submitted holds promise of confirming the claims made for the device, confirmatory tests of the device are scheduled at the EPA Emissions Laboratory at Ann Arbor, Michigan. The results of all such confirmatory test projects are set forth in a series of Technology Assessment and Evaluation Reports, of which this report is one.

The conclusions drawn from the EPA confirmatory tests are necessarily of limited applicability. A complete evaluation of the effectiveness of an emission control system in achieving its claimed performance improvements on the many different types of vehicles that are in actual use requires a much larger sample of test vehicles than is economically feasible in the confirmatory test projects conducted by EPA. 1/ For promising devices it is necessary that more extensive test programs be carried out.

The conclusions from the EPA confirmatory tests can be considered to be quantitatively valid only for the specific type of vehicle used in the EPA confirmatory test program. Although it is reasonable to extrapolate the results from the EPA confirmatory test to other types of vehicles in a directional manner, i.e., to suggest that similar results are likely to be achieved on other types of vehicles, tests of the device on such other vehicles would be required to reliably quantify results on other types of vehicles.

In summary, a device that lives up to its claims in the EPA confirmatory test must be further tested according to protocols described in footnote 1/, to quantify its beneficial effects on a broad range of vehicles. A device which when tested by EPA does not meet the claimed results would not appear to be a worthwhile candidate for such further testing from the standpoint of the likelihood of ultimately validating the claims made. However, a definitive quantitative evaluation of its effectiveness on a broad range of vehicle types would equally require further tests in accordance with footnote 1/.

1/ See Federal Register 38 FR 11334, 3/27/74, for a description of the test protocols proposed for definitive evaluations of the effectiveness of retrofit devices.

Data supplied to the EPA by Ball-Matic, Inc., indicated that their emission control device (called the Ball-Matic) was capable of reducing exhaust emissions. Consequently, an EPA confirmatory test program was arranged to further investigate the effects of the Ball-Matic on exhaust emissions.

## Test Vehicle and Device Description

The vehicle used in the test program was a 1970 Plymouth Valiant powered by a 225 cu in. 6 cylinder engine and equipped with an automatic transmission. A tabulation of vehicle statistics is given on the vehicle description sheet at the end of this report.

The Ball-Matic is essentially an air-bleed device that is installed in the PCV line (see Figure 1). Air enters the top of the Ball-Matic, passes through a ball-and-spring type valve, and enters the PCV line. Under conditions of low manifold vacuum, the ball-and-spring valve is designed to close, preventing air from being drawn through the Ball-Matic and into the PCV line.

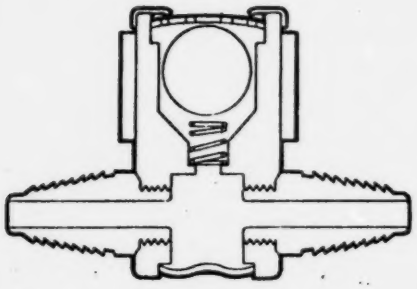

Figure 1: Cross Sectional View of the Ball-Matic

## Test Program

Exhaust emission and fuel economy tests were conducted in accordance with the 1975 Federal Test Procedure ('75 FTP) and the EPA Highway Fuel Economy Test (HFET).

Tests were conducted with and without the Ball-Matic installed on the test vehicle. For baseline tests, the vehicle was adjusted according to the manufacturer's tune-up specifications. In the baseline configuration the vehicle was tested twice in accordance with the '75 FTP and HFET.

After completing the baseline tests, the Ball-Matic was installed in the PCV line as directed in the instructions supplied with the Ball-Matic. With the Ball-Matic installed, the vehicle was again tested twice in accordance with the '75 FTP and HFET.

Test Results

Exhaust emission data, summarized below, illustrate the effects of the Ball-Matic.

1975 Federal Test Procedure
Mass emissions in
grams per mile
(grams per kilometer)

| | HC | CO | NOx | Fuel Economy (Fuel Consumption) |
|---|---|---|---|---|
| Baseline - avg. of 2 tests | 2.80 (1.74) | 35.1 (21.8) | 5.52 (3.43) | 19.1 miles/gal (12.3 liters/100 km) |
| Ball-Matic - avg. of 2 tests | 2.68 (1.66) | 32.2 (20.0) | 5.75 (3.58) | 19.0 miles/gal (12.4 liters/100 km) |
| % Change from baseline | -4% | -8% | +4% | -1% (+1%) |

Highway Fuel Economy Test
Mass emissions in
grams per mile
(grams per kilometer)

| | HC | CO | NOx | Fuel Economy (Fuel Consumption) |
|---|---|---|---|---|
| Baseline - avg. of 2 tests | 1.29 (0.81) | 8.9 (5.5) | 6.10 (3.79) | 26.4 miles/gal (8.9 liters/100 km) |
| Ball-Matic - avg. of 2 tests | 1.24 (0.77) | 7.7 (4.9) | 6.33 (3.94) | 26.3 miles/gal (8.9 liters/100 km) |
| % Change from baseline | -4% | -13% | +4% | 0 |

The effects of the Ball-Matic on exhaust emissions are the results of mixture enleanment caused by bleeding air into the PCV line. This is evidenced by the decreases in HC and CO emissions coupled with increased in NOx emissions during the '75 FTP and HFET. Fuel economy was not affected by the Ball-Matic.

A further breakdown of '75 FTP and HFET emissions can be found in Tables I-III.

## Conclusions

1. The Ball-Matic caused small reductions in emissions of unburned hydrocarbons and carbon monoxide due to enleanment of the air-fuel ratio. A small increase in oxide of nitrogen emissions occurred as a result of the mixture enleanment.

2. The Ball-Matic had no significant effect on fuel economy.

Table I
1975 Federal Test Procedure
mass emissions in
grams per mile
(grams per kilometer)

| Test # | HC | CO | $CO_2$ | NOx | miles/gal. (liters/100 km) |
|---|---|---|---|---|---|
| Baseline | | | | | |
| 77-1982 | 2.86<br>(1.78) | 35.5<br>(22.1) | 400.<br>(248.) | 5.43<br>(3.37) | 19.1<br>(12.3) |
| 77-1863 | 2.73<br>(1.70) | 34.7<br>(21.5) | 403.<br>(250.) | 5.60<br>(3.48) | 19.0<br>(12.3) |
| Average | 2.80<br>(1.74) | 35.1<br>(21.8) | 402.<br>(249.) | 5.52<br>(3.43) | 19.1<br>(12.3) |
| Ball-Matic Installed | | | | | |
| 77-1587 | 2.76<br>(1.71) | 33.7<br>(20.9) | 417.<br>(259.) | 5.90<br>(3.67) | 18.5<br>(12.7) |
| 77-2047 | 2.59<br>(1.61) | 30.7<br>(19.1) | 398.<br>(247.) | 5.60<br>(3.48) | 19.5<br>(12.0) |
| Average | 2.68<br>(1.66) | 32.2<br>(20.0) | 408.<br>(253.) | 5.75<br>(3.58) | 19.0<br>(12.4) |

Table II
'75 FTP individual bag emissions in
grams per mile

| Test # | Bag 1: Cold Transient | | | | | Bag 2: Stabilized | | | | | Bag 3: Hot Transient | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HC | CO | $CO_2$ | NOx | mpg | HC | CO | $CO_2$ | NOx | mpg | HC | CO | $CO_2$ | NOx | mpg |
| **Baseline** | | | | | | | | | | | | | | | |
| 77-1982 | 5.81 | 91.1 | 393. | 5.12 | 16.0 | 2.25 | 23.6 | 412. | 5.09 | 19.4 | 1.80 | 16.5 | 381. | 6.32 | 21.5 |
| 77-1863 | 5.36 | 89.8 | 397. | 5.28 | 16.0 | 2.15 | 21.9 | 416. | 5.26 | 19.4 | 1.86 | 17.6 | 382. | 6.47 | 21.4 |
| **Ball-Matic Installed** | | | | | | | | | | | | | | | |
| 77-1587 | 5.13 | 88.9 | 414. | 5.72 | 15.6 | 2.20 | 20.9 | 429. | 5.49 | 18.9 | 2.03 | 16.5 | 396. | 6.83 | 20.7 |
| 77-2047 | 4.43 | 74.1 | 334. | 4.41 | 19.1 | 2.20 | 20.7 | 427. | 5.50 | 19.0 | 1.96 | 17.0 | 391. | 6.71 | 20.9 |

Table III
Highway Fuel Economy Test
mass emissions in
grams per mile
(grams per kilometer)

| Test # | HC | CO | $CO_2$ | NOx | miles/gal. (liters/100 km) |
|---|---|---|---|---|---|
| **Baseline** | | | | | |
| 77-1983 | 1.28<br>(0.80) | 8.8<br>(5.5) | 315.<br>(196.) | 5.86<br>(3.64) | 26.7<br>(8.8) |
| 77-1586 | 1.30<br>(0.81) | 8.9<br>(5.5) | 322.<br>(200.) | 6.34<br>(3.94) | 26.1<br>(9.0) |
| Average | 1.29<br>(0.81) | 8.9<br>(5.5) | 319.<br>(198.) | 6.10<br>(3.79) | 26.4<br>(8.9) |
| **Ball-Matic Installed** | | | | | |
| 77-2048 | 1.22<br>(0.76) | 7.3<br>(4.6) | 322.<br>(200.) | 6.38<br>(3.97) | 26.3<br>(8.9) |
| 77-2049 | 1.26<br>(0.78) | 8.1<br>(5.1) | 321.<br>(199.) | 6.28<br>(3.90) | 26.3<br>(8.9) |
| Average | 1.24<br>(0.77) | 7.7<br>(4.9) | 322.<br>(200.) | 6.33<br>(3.94) | 26.3<br>(8.9) |

## TEST VEHICLE DESCRIPTION

**Chassis model year/make - 1970 Plymouth Valiant**
**Emission control system - Engine Modifications**

### Engine

| | |
|---|---|
| type | 4 stroke, Otto cycle, I-6, ohv |
| bore x stroke | 3.40 x 4.12 in./86.4 x 104.7 mm |
| displacement | 225 cu in./3688 cc |
| compression ratio | 8.4:1 |
| maximum power at rpm | 145 bhp/108 kW at 4000 rpm |
| fuel metering | one barrel carburetor |
| fuel requirement | regular leaded |

### Drive Train

| | |
|---|---|
| transmission type | 3 speed automatic |
| final drive ratio | |

### Chassis

| | |
|---|---|
| type | front engine, rear wheel drive |
| tire size | FR 78x14 |
| curb weight | |
| inertia weight | 3000 lbs. |
| passenger capacity | 6 |

### Emission Control System

| | |
|---|---|
| basic type | engine modifications |
| durability accumulated on system | 23000 mi./37000 km |